ET 98-153

UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Washington, D.C. 20230

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Federal Communications Commission
Office of the Secretary

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Mr. Edmond J. Thomas
Chief, Office of Engineering and Technology
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Dear Mr. Thomas:

The National Telecommunications and Information Administration (NTIA) appreciates the opportunity to provide comments in response to the Federal Communications Commission (Commission) draft Second Report and Order and Second Memorandum Opinion and Order (R&O and MO&O) revising the Part 15 Rules regarding ultrawideband (UWB) transmission systems.[1] NTIA supports many of the Commission's proposals contained in the draft R&O and MO&O. However, there are proposals related to wideband unlicensed device operation in the 5925-7250 MHz and 16.2-16.7 GHz bands, non-UWB vehicular radars operating in the 22-29 GHz frequency range, and modification of the compliance measurement procedures for certain modulation types that were not contained in the Commission's Further Notice of Proposed Rulemaking on UWB transmission systems.[2] Since these new proposals have a potential impact on federal operations, NTIA would like to highlight its concerns.

For wideband unlicensed device operation in the 5925-7250 MHz and 16.2-16.7 GHz bands, the Commission is proposing that the radiated emission levels outside of these bands and above 960 MHz are limited to an equivalent isotropically radiated power (EIRP) level of -51.3 dBm/MHz.[3] NTIA cannot support this proposal because there is no technical basis provided for the proposed EIRP level of -51.3 dBm/MHz. While the text states that "the UWB emission limits were based on several interference analyses and were found to be sufficient to prevent harmful interference," the Commission does not provide rationale for ignoring the emission limits for UWB devices below 3.1 GHz and adopting a limit of -51.3 dBm/MHz. A further problem with this proposal is that the Commission is now permitting a non-UWB device to have emissions in the frequency bands below 3.1 GHz at much higher levels than are currently permitted for UWB transmission systems. For example, the limits are 24 dB higher in the GPS frequency bands. If devices that can have bandwidths commensurate with those permitted under the UWB rules are allowed to operate in the 5925-7250 MHz and 16.2-17.7 GHz bands, then the UWB device manufacturers can claim that they are at a technical disadvantage and must be allowed to operate at -51.3 dBm/MHz below 3.1 GHz. In light of the fact that the Commission has not provided

1. *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, Draft Second Report and Order and Second Memorandum Opinion and Order, ET Docket No. 98-153, (November 2004) ("Draft R&O and MO&O").

2. *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, Memorandum Opinion and Order and Further Notice of Proposed Rulemaking, ET Docket No. 98-153, (released March 12, 2003).

3. Draft R&O and MO&O at ¶ 26.

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has not provided technical justification for the -51.3 dBm/MHz, we do not believe that the disparate treatment of UWB and "near-UWB" broadband devices will be sustainable. For the 5925-7250 MHz band, NTIA proposes that the emission limits for UWB hand-held devices be adopted for radiated emissions outside of the band of operation and above 960 MHz. For the 16.2-17.7 GHz band, NTIA proposes that the emission limits for UWB vehicular radar systems be adopted outside of the band of operation and above 960 MHz. The proposed modifications to the rules contained in Appendix A of the draft R&O and MO&O are provided in Enclosure A of this letter.

The Commission is proposing a new rule part that would allow non-UWB vehicular radar systems to operate in the 22-29 GHz frequency range regardless of the type of modulation that is employed.[4] Specifically, the Commission proposes to allow frequency hopping vehicular radar systems as well as non-hopping vehicular radar systems that employ a bandwidth of less than 500 MHz required for operation under the UWB standards. As a matter of policy, NTIA has opposed the intentional generation of emissions in the restricted frequency bands. Exceptions to this long standing policy were made to accommodate UWB vehicular radar systems that also employ a long range mode of operation in the 24-24.25 GHz Industrial, Scientific, and Medical (ISM) band.[5] Under the Commission's UWB Rules, vehicular radar systems are permitted to operate in the 23.6-24 GHz restricted frequency band that is allocated to the Earth Exploration Satellite Service (EESS) used by passive sensors that collect data supporting long-range numerical weather prediction forecasts.[6] Because of the extremely large bandwidths required for UWB systems and the location of the ISM band, avoiding the 23.6-24 GHz band was not possible without impacting the performance and costs of the current vehicular radar system designs.

The Commission's proposal permitting the non-UWB vehicular radar systems to transmit in the 23.6-24 GHz band could establish a precedent by allowing other types of narrow band unlicensed devices to operate in the restricted frequency bands. The UWB rules were implemented to permit systems that because of their extremely wide bandwidths, were unable to avoid operation within the restricted frequency bands. Narrow band frequency hopping vehicular radar systems and other narrow band non-hopping vehicular radar systems, on the other hand can operate while avoiding the restricted bands. Requiring such non-UWB vehicular radars to avoid the 400 MHz used for passive sensing should not degrade the performance or increase the costs of the radar systems. Unlike conventional UWB devices, frequency hopping systems have greater flexibility in determining which frequency bands will be employed and which will not.

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4. Draft R&O and MO&O at ¶ 47.

5. Some vehicular radar designs have a low-power short-range mode of operation using UWB and a long-range mode of operation using a narrow band signal in the ISM band, where higher power levels are permitted. To reduce cost and simplify their, current design manufacturers use the same local oscillator for the short and long range modes of the vehicular radars.

6. The numerical weather prediction models provide forecasts from 6 to 240 hours into the future and are usually updated every 6 hours. The same input data is used for the complete range of forecasts periods. The expected progress of weather systems is important for taking necessary actions to respond to both short- and long-term weather effects (e.g., heavy rains and the resulting floods) on every day life.

Similarly, narrow band non-hopping vehicular radar systems have sufficient bandwidth available in the remainder of the 22-29 GHz band with which to operate. A waiver was issued to Siemens VDO to permit the introduction of its frequency hopping vehicular radar system.[7] As a condition of that waiver, Siemens VDO agreed that its equipment can function while avoiding transmitting in the 23.6-24 GHz restricted frequency band. Thus, by agreeing to the conditions of the waiver, Siemens has already demonstrated that its equipment can be designed to function while avoiding the 23.6-24 GHz band.

NTIA proposes that all non-UWB vehicular radar systems operating in the 22-29 GHz band, regardless of the type of modulation employed, not be permitted in the 23.6-24 GHz restricted band. Only unintentional emissions from non-UWB vehicular radars should be permitted in the 23.6-24 GHz band. Furthermore, the unintentional emissions that do appear in the 23.6-24 GHz band must be attenuated by at least 20 dB below the general emission limits specified in Part 15.209 of the Commission's Rules (e.g., an EIRP of -61.3 dBm/MHz). Similarly, non-UWB vehicular radars should be excluded from operating in the 22.01-23.12 GHz restricted frequency band.[8] It should also be brought to your attention that EESS sensors and their protection criteria are evolving and have become more sensitive in response to the need for greater resolution data. This factor will have to be taken into account in any future consideration of the 23.6-24 GHz band. The proposed modifications to the rules contained in Appendix A of the draft R&O and MO&O are provided in Enclosure A of this letter.

The Commission has also proposed changes to the compliance measurement procedures for unlicensed devices employing frequency hopping, swept frequency, and stepped frequency techniques as well as for devices that employ gating. The proposed compliance measurement procedures would be adopted in all of the new rule sections being proposed in the R&O and MO&O. The Commission is proposing to perform the compliance measurements with the frequency hopping, sweeping, stepping and gating function turned on, whereas the current procedures are performed with the frequency hopping, sweeping, stepping, and gating functions turned off.

The Commission's FNPRM only addressed compliance measurement procedures for frequency hopping vehicular radar systems operating in the 22-29 GHz frequency range. In response to the questions in the FNPRM, NTIA provided a proposal for the compliance measurements for this specific device application and modulation technique.[9] NTIA agrees with the Commission that compliance measurement procedures should not be developed that provide an advantage to one technology over another. NTIA believes that performing the compliance

7. A waiver was issued to Siemens VDO on June 25, 2003, by letter under delegated authority of the Chief, Office of Engineering and Technology.

8. The 22.235 GHz water vapor line, listed among the radio frequency lines of greatest importance to radio astronomy in Recommendation ITU-R RA.314 is in the 22.01-23.12 GHz restricted frequency band.

9. National Telecommunications and Information Administration, Late-Filed Comments, ET Docket No. 98-153 (January 15, 2004) at Appendix D.

measurements of systems with the frequency hopping, sweeping, stepping or gating function turned on provides a more meaningful representation of the emissions generated by a device. This information can be used in assessing potential interference to other radio services. Developing procedures for the compliance measurements is seen by NTIA as an essential element in accepting the Commission's proposal. NTIA believes that the measurement procedures developed for the systems employing frequency hopping can be extended to include devices employing stepped frequency techniques[10] or gating. Enclosures B and C of this letter provide compliance measurement guidance for devices employing frequency hopping and stepping and devices employing gating. These guidelines can be included as part of the Commission's Interpretations Database used by the Telecommunication Certification Bodies responsible for performing the compliance measurements. NTIA recognizes that these are only guidelines that can be changed at any time by the Commission as more experience is gained with measuring actual devices.

The FNPRM did not address compliance measurement issues related to devices that employ frequency sweeping. Based on waiver requests before the Commission, NTIA has begun investigating the different technical aspects of measuring swept frequency systems.[11] We are therefore requesting that the Commission defer any change regarding the compliance measurements for swept frequency unlicensed devices until NTIA has completed its study.

We strongly recommend that the Commission include the enclosed information in the service rules being adopted in the R&O and MO&O. If you have any questions about our comments, please feel free to contact me at 202-482-1850.

Sincerely,

Fredrick R. Wentland
Associate Administrator
Office of Spectrum Management

Enclosures

10. For systems employing stepped frequency techniques each frequency step is analogous to a frequency hop.

11 Safeview, Inc. Request for Waiver of Sections 15.31 and 15.35 of the Commission's Rules to permit the Deployment of Security Screening Portal Devices that Operate in the 24.25-30 GHz Range (August 18, 2004).

ENCLOSURE A

Appendix A
Changes to the Regulations

Title 47 of the Code of Federal Regulations, Part 15, is amended as follows:

1. The authority citation for Part 15 continues to read as follows:

AUTHORITY: 47 U.S.C. 154, 302, 303, 304, 307, 336 and 544A.

2. Section 15.35 is amended by revising paragraph (b) to read as follows:

Section 15.35 Measurement detector functions and bandwidths.

* * * * *

(b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, *e.g.*, see §§ 15.250, 15.252, 15.255, and 15.509-15.519 of this part, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device, *e.g.*, the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

* * * * *

~~3. Section 15.205 is amended by adding a new paragraph (d)(10), to read as follows:~~

~~Section 15.205 Restricted bands of operation.~~

~~* * * * *~~

~~(d)(10) Transmitters operating in the 22.0-29.0 GHz band pursuant to Section 15.252 of this part are exempt from complying with this section for the 22.01-23.12 GHz and 23.6-24.0 GHz bands only. Transmitters operating pursuant to Section 15.250 or Section 15.252 of this part shall not exceed the limits specified in those sections for emissions appearing within any of the restricted bands.~~

* * * * *

4. A new Section 15.250 is added to read as follows:

Section 15.250 Operation of wideband systems within the band 5925-7250 MHz.

(a) The -10 dB bandwidth of a device operating under the provisions of this section must be contained within the 5925-7250 MHz band. Operation on board an aircraft or a satellite is prohibited. Devices operating under this section may not be employed for the operation of toys. Except for operation onboard a ship or a terrestrial transportation vehicle, the use of a fixed outdoor infrastructure is prohibited. A fixed infrastructure includes antennas mounted on outdoor structures, *e.g.*, antennas mounted on the outside of a building or on a telephone pole.

(b) The -10 dB bandwidth of the ~~transmission~~ fundamental emission shall be at least 50 MHz and shall be contained within the 5925-7250 MHz band under all conditions of operation including effects from the frequency stability of the transmitter over expected variations in temperature and supply voltage. The frequency at which the highest level emission occurs shall be contained within this -10 dB bandwidth under all conditions of modulation.

(c) The radiated emissions at or below 960 MHz shall not exceed the emission levels in Section 15.209 of this part. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following RMS average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	-75.3
1610-1990	-63.3
1990-5925	-51.3
5925-7250	-41.3
7250-10600	-51.3
Above 10600	-61.3

(d) In addition to the radiated emission limits specified in paragraph (c) of this section, transmitters operating under the provision of this section shall not exceed the following RMS average limits when measured using a resolution bandwidth on no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	-85.3
1559-1610	-85.3

~~The radiated emissions within the 5925-7250 MHz band of operation shall not exceed an equivalent isotropically radiated power (EIRP) RMS average level of -41.3 dBm. The radiated emissions above 960 MHz and outside of the frequency band of operation shall not exceed an EIRP RMS average~~

~~level of 51.3 dBm. However,~~

(c) eEmissions from digital circuitry used to enable the operation of the transmitter may comply with the limits in Section 15.209 of this chapter provided it can be clearly demonstrated that those emissions are due solely to emissions from digital circuitry contained within the transmitter and the emissions are not intended to be radiated from the transmitter's antenna. Emissions from associated digital devices, as defined in Section 15.3(k) of this chapter, *e.g.*, emissions from digital circuitry used to control additional functions or capabilities other than the operation of the transmitter, are subject to the limits contained in Subpart B of Part 15 of this chapter. Emissions from these digital circuits shall not be employed in determining the -10 dB bandwidth of the fundamental emission or the frequency at which the highest emission level occurs.

(~~d~~f) There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs. The peak EIRP limit is 20 log (RBW/50) dBm where RBW is the resolution bandwidth in megahertz that is employed by the measurement instrument. RBW shall not be lower than 1 MHz or greater than 50 MHz. The video bandwidth of the measurement instrument shall not be less than RBW. If RBW is greater than 3 MHz, the application for certification filed with the Commission shall contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

(e) Measurement procedures:

(1) All emissions at and below 960 MHz are based on measurements employing a CISPR quasi-peak detector. All RMS average emission levels specified in this section are to be measured utilizing a 1 MHz resolution bandwidth with a one millisecond dwell over each 1 MHz segment. The frequency span of the analyzer should equal the number of sampling bins times 1 MHz and the sweep rate of the analyzer should equal the number of sampling bins times one millisecond. **[Note – the language of the last 2 sentences is still under review.]** The provision in Section 15.35(c) of this part that allows emissions to be averaged over a 100 millisecond period does not apply to devices operating under this section. The video bandwidth of the measurement instrument shall not be less than the resolution bandwidth and trace averaging shall not be employed. The RMS average emission measurement is to be repeated over multiple sweeps with the analyzer set for maximum hold until the amplitude stabilizes.

(2) All peak power (EIRP) emission measurements specified in this section are to be measured utilizing a resolution bandwidth (RBW) not lower than 1 MHz or greater than 50 MHz. The video bandwidth must be equal to or greater than the RBW. The peak power is to be measured over a 10 millisecond dwell time for each segment of the sweep. The peak power measurement is to be repeated over multiple sweeps, with the spectrum analyzer set for maximum hold, until the amplitude stabilizes.

(3~~2~~) For transmitters that employ frequency hopping ~~swept frequency,~~ stepped frequency or similar modulation types, measurement of the -10 dB bandwidth shall be made with the frequency hop, ~~sweep~~ or step function disabled and with the transmitter operating continuously at a

fundamental frequency following the provisions of Section 15.31(m) of this part. The peak emission level measurement, the measurement of the RMS average emission levels, and the measurement to determine the frequency at which the highest level emission occurs shall be made with the frequency hop ~~sweep~~ or step function active. Gated signals may be measured with the gating active.

(~~4~~3) The -10 dB bandwidth is based on measurement using a peak detector, a 1 MHz resolution bandwidth, and a video bandwidth greater than or equal to the resolution bandwidth.

(5) The measurements must be performed for all of the operational modes of the device.

(6) Systems employing swept modulation techniques are to be measured with the frequency sweeping function turned off.

(4~~7~~) Alternative measurement procedures may be considered by the Commission. A detailed description of the alternative measurement procedures must be provided by the applicant.

5. A new Section 15.252 is added to read as follows:

Section 15.252 Operation of wideband vehicular radar systems within the bands 16.2-17.7 GHz and 22.0-29.0 GHz.

(a) Operation under this section is limited to field disturbance sensors that are mounted in terrestrial transportation vehicles. Operation within the 16.2-17.7 GHz band is limited to field disturbance sensors that are used only for back-up assistance and that operate only when the vehicle is engaged in reverse.

(1) If frequency hopping modulation is employed, the system shall hop at the system hopping rate to channel frequencies that are selected from a pseudorandomly order list of frequencies. Each frequency must be used equally on the average by each transmitter. Hopping channels shall not overlap. The hopping channel carrier frequencies must be separated by at least the -10 dB hopping channel bandwidth.

(2) The -10 dB bandwidth of the fundamental emission shall be 10 MHz or greater. The -10 dB bandwidth of the fundamental emission shall be located within the 16.2-17.7 GHz band or the 22.0-29.0 GHz band, excluding the 22.01-23.12 GHz and 23.6-24 GHz bands as appropriate, at all times. This requirement includes any effects from the frequency stability of the transmitter over expected variations in temperature and supply voltage as well as any effects from the type of modulation employed. The frequency at which the highest level emission occurs shall be contained within this -10 dB bandwidth under all conditions of modulation.

(3) For systems operating in the 22.0-29.0 GHz band, the frequencies at which the highest average emission level and at which the highest peak level emission appear shall be greater than 24.075 GHz. ~~and the center frequency, as determined by (the frequency of the upper -10 dB~~

~~bandwidth point minus the frequency of the lower 10 dB bandwidth point)/2, shall be greater than 24.075 GHz.~~

(4) These devices shall operate only when the vehicle is operating, *e.g.*, the engine is running. Operation shall occur only upon specific activation, such as upon starting the vehicle, changing gears, or engaging a turn signal. The operation of these devices shall be related to the proper functioning of the transportation vehicle, *e.g.*, collision avoidance.

(b) For vehicular radars operating ~~Emissions~~ within the 16.2-17.7 GHz frequency range the emission levels are as follows ~~band of operation shall not exceed an equivalent isotropically radiated power (EIRP) density level of~~:

(1) The radiated emissions at or below 960 MHz shall not exceed the emission levels in Section 15.209 of this part. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following RMS average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	-75.3
1610-16200	-61.3
16200-17700	-41.3
Above 17700	-61.3

(2) In addition to the radiated emission limits specified in paragraph (1) of this section, transmitters operating under the provision of this section shall not exceed the following RMS average limits when measured using a resolution bandwidth on no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	-85.3
1559-1610	-85.3

(c) For vehicular radars operating within the 22-29 GHz frequency range the emission levels are as follows:

(1) The radiated emissions at or below 960 MHz shall not exceed the emission levels in Section 15.209 of this part. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following RMS average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	-75.3
1610-22000	-61.3
22000-22010	-41.3
22010-23120	-61.3

23120-23600	-41.3
23600-24000	-61.3
24000-29000	-41.3
29000-31000	-51.3
Above 31000	-61.3

(2) In addition to the radiated emission limits specified in paragraph (1) of this section, transmitters operating under the provision of this section shall not exceed the following RMS average limits when measured using a resolution bandwidth on no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	-85.3
1559-1610	-85.3

~~(1) -41.3 dBm RMS average based on a 1 MHz resolution bandwidth, except as follows: following proper installation, vehicular radar systems operating in the 22.0-29.0 GHz band shall attenuate any emissions within the 23.6-24.0 GHz band that appear 38 degrees or greater above the horizontal plane to an RMS average level of -66.3 dBm. For equipment authorized, manufactured or imported on or after January 1, 2005, vehicular radar systems shall attenuate any emissions within the 23.6-24.0 GHz band that appear 30 degrees or greater above the horizontal plane to an RMS average level of -66.3 dBm. For equipment authorized, manufactured or imported on or after January 1, 2010, vehicular radar systems shall attenuate any emissions within the 23.6-24.0 GHz band that appear 30 degrees or greater above the horizontal plane to an RMS average level of -71.3 dBm. For equipment authorized, manufactured or imported on or after January 1, 2014, vehicular radar systems shall attenuate any emissions within the 23.6-24.0 GHz band that appear 30 degrees or greater above the horizontal plane to an RMS average level of -76.3 dBm. Compliance with the emission levels in the 23.6-24.0 GHz band can be achieved through antenna directivity, through a reduction in output power, or through any other means.~~

(2d) The peak EIRP limit is 20 log (RBW/50) dBm ~~peak~~ as based on measurements using a peak detector where RBW is the resolution bandwidth in MHz employed by the measurement instrument. RBW shall not be lower than 1 MHz or greater than 50 MHz. Further, RBW shall not be greater than the -10 dB bandwidth of the device under test. The video bandwidth of the measurement instrument shall not be less than RBW. The limit on peak emissions applies to the 50 MHz bandwidth centered on the frequency at which the highest level radiated emission occurs. If RBW is greater than 3 MHz, the application for certification shall contain a detailed description of the test procedure, the instrumentation employed in the testing, and the calibration of the test setup.

(c) ~~The radiated emissions at or below 960 MHz shall not exceed the emission levels in Section 15.209 of this part. The radiated emissions above 960 MHz and outside of the frequency band of operation shall not exceed an EIRP RMS average level of -51.3 dBm. However, e~~Emissions from digital circuitry used to enable the operation of the transmitter may comply with the limits in Section 15.209 of this chapter provided it can be clearly demonstrated that those emissions are due solely to

emissions from digital circuitry contained within the transmitter and the emissions are not intended to be radiated from the transmitter's antenna. Emissions from associated digital devices, as defined in Section 15.3(k) of this chapter, *e.g.*, emissions from digital circuitry used to control additional functions or capabilities other than the operation of the transmitter, are subject to the limits contained in Subpart B of Part 15 of this chapter. Emissions from these digital circuits shall not be employed in determining the -10 dB bandwidth of the fundamental emission or the frequency at which the highest emission level occurs.

(cd) Measurement procedures:

(1) All emissions at and below 960 MHz are based on measurements employing a CISPR quasi-peak detector. All RMS average emission levels specified in this section are to be measured utilizing a 1 MHz resolution bandwidth with a one millisecond dwell over each 1 MHz segment. The frequency span of the analyzer should equal the number of sampling bins times 1 MHz and the sweep rate of the analyzer should equal the number of sampling bins times one millisecond. **[Note – the language of the last 2 sentences is still under review.]** The provision in Section 15.35(c) of this part that allows emissions to be averaged over a 100 millisecond period does not apply to devices operating under this section. The video bandwidth of the measurement instrument shall not be less than the resolution bandwidth and trace averaging shall not be employed. The RMS average emission measurement is to be repeated over multiple sweeps with the analyzer set for maximum hold until the amplitude stabilizes.

(2) All peak power (EIRP) emission measurements specified in this section are to be measured utilizing a resolution bandwidth (RBW) not lower than 1 MHz or greater than the -10 dB bandwidth of the device under test. The video bandwidth must be equal to or greater than the RBW. The peak power is to be measured over a 10 millisecond dwell time for each segment of the sweep. The peak power measurement is to be repeated over multiple sweeps, with the spectrum analyzer set for maximum hold, until the amplitude stabilizes.

(32) For transmitters that employ frequency hopping, ~~swept frequency,~~ stepped frequency or similar modulation types, measurement of the -10 dB bandwidth shall be made with the frequency hop, ~~sweep~~ or step function disabled and with the transmitter operating continuously at a fundamental frequency following the provisions of Section 15.31(m) of this part. The peak emission level measurement, the measurement of the RMS average emission levels, the measurement to determine the center frequency, and the measurement to determine the frequency at which the highest level emission occurs shall be made with the frequency hop, ~~sweep~~ or step function active. Gated signals may be measured with the gating active.

(43) The -10 dB bandwidth is based on measurement using a peak detector, a 1 MHz resolution bandwidth, and a video bandwidth greater than or equal to the resolution bandwidth.

(5) Systems employing swept modulation techniques are to be measured with the frequency sweeping function turned off.

(64) Alternative measurement procedures may be considered by the Commission. A detailed description of the alternative measurement procedures must be provided by the applicant.

ENCLOSURE B

GUIDANCE FOR COMPLIANCE MEASUREMENTS OF FREQUENCY HOPPING VEHICULAR RADAR SYSTEMSOPERATING IN THE 22-29 GHz FREQUENCY RANGE

INTRODUCTION

The purpose of this document is to provide guidance on performing the compliance measurements for frequency hopping vehicular radar systems operating in the 22-29 GHz frequency range. These measurement guidelines can also be applied to systems employing stepped frequency techniques as each frequency step is analogous to a frequency hop.

FREQUENCY HOPPING SYSTEM PARAMETERS REQUIRED FOR CERTIFICATION

The emission characteristics of a frequency hopping signal are defined by its system parameters. The applicant requesting device certification should be required to provide the following system parameters: pulse width, antenna polarization, pulse repetition frequency (PRF), frequency hopping bandwidth, number of frequency hopping channels, hopping channel frequency separation, the time length of the frequency hopping sequence, and the frequency hopping pattern (e.g., pseudo random, linear step). These parameters will define a specific mode of operation for the vehicular radar. If there are multiple operating modes the system parameters for each mode are to be provided by the applicant and each of the multiple modes is to be tested for certification.

OVERVIEW OF CERTIFICATION MEASUREMENT PROCEDURES

The general measurement setup used in the certification measurements is shown in Figure 1.

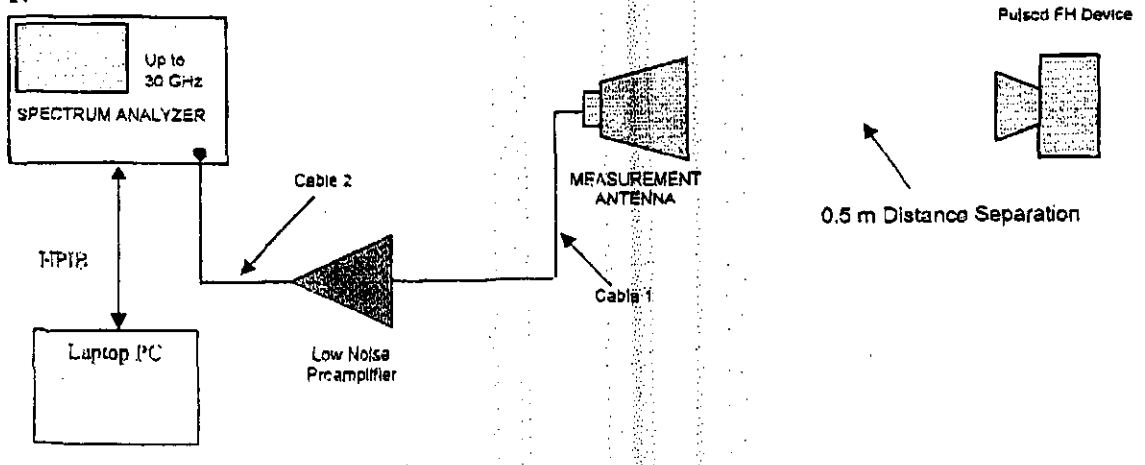

Figure 1. General Test Setup

The certification measurements will require two test setups. The first test setup will be used to measure the emission characteristics of the unit under test (UUT) primarily within the 22 to 29 GHz frequency range. The second test setup will be used to measure emission characteristics in the 1 to 3 GHz frequency range. Both test setups will use the equipment shown in Figure 1, the only difference will be the applicable frequency range of the preamplifier and the measurement antenna.

The 22 to 29 GHz frequency range test setup will use a 0.5 meter separation distance with no surface that could provide significant reflections in the vicinity of the test setup. The UUT including the transmit antenna is to be located at a height of approximately 1 to 2 meters. The required commercially available measurement equipment includes:

- A spectrum analyzer with peak and RMS detectors, maximum hold[1] capability, and a minimum upper frequency capability of 30 GHz;

- An appropriate measurement antenna with a gain on the order of 15 dBi over the approximate frequency range of 20 to 30 GHz. This antenna is to be oriented in the test setup such that the polarization is aligned with the polarization of the antenna used by the UUT. The measurement is to be at the same height as the UUT antenna.;

- A low noise preamplifier with a gain of at least NF + L + 5 dB, where NF is the noise figure of the spectrum analyzer, and L is the loss of the cable connecting the low noise preamplifier to the spectrum analyzer. The values of NF and L may be determined from specifications or measurements. The low noise preamplifier should have a noise figure of less than 2 dB over the frequency range of 20 to 30 GHz;

- Low loss cable to connect measurement antenna to low noise preamplifier input with a cable loss on the order of 0.2 dB at 24 GHz;

- Suitable cable(s) are required to connect the low noise preamplifier output to the spectrum analyzer. This connection might require a variable attenuator to avoid saturation;

- A personal computer connected to the spectrum analyzer is recommended to control the analyzer and to store the measured data.

The 1 to 3 GHz measurement setup requires the following commercially available measurement equipment:

- A spectrum analyzer with peak and RMS detectors, maximum

1. The maximum hold capability retains the maximum value for each point on the spectrum analyzer display over the selected number of display scans.

hold capability, and a minimum upper frequency capability of 30 GHz;

- An appropriate measurement antenna with a gain on the order of 10 dBi over the approximate frequency range of 1 to 3 GHz (a minimum antenna gain of 8 dBi is required across the 1170 to 1580 MHz frequency range). This antenna is to be oriented in the test setup such that the polarization is aligned with the polarization of the antenna used by the UUT. The measurement antenna is to be at the same height as the UUT antenna.;

- Low noise preamplifier with a gain of at least NF + L + 5 dB, where NF is the noise figure of the spectrum analyzer, and L is the loss of the cable connecting the low noise preamplifier to the spectrum analyzer. The value of NF and L may be determined from specifications or measurements. The low noise preamplifier should have a noise figure of less than 2 dB over the frequency range of 1 to 3 GHz;

- Low loss cable to connect measurement antenna to low noise preamplifier input with a cable loss on the order of 0.2 dB at 2 GHz;

- Suitable cable(s) are required to connect the low noise preamplifier output to the spectrum analyzer. This connection might require a variable attenuator to avoid saturation;

- A personal computer connected to the spectrum analyzer is recommended to control the analyzer and to store the measured data.

Measurement of Peak Power Levels

These measurements are to be carried out using the first measurement setup. The UUT antenna is to be pointed directly at the measurement antenna with the polarization of the UUT and the measurement antenna matched. With the UUT operating in the frequency hopping mode[2] the spectrum analyzer is to be set to the peak detector mode (with maximum hold) with a resolution bandwidth of 3 MHz and video bandwidth of at least 3 MHz. The peak power levels of the UUT should be measured across the range of 22 to 29 GHz over a 10 millisecond dwell time for each segment of the sweep. This peak power measurement is to be repeated, with the analyzer in the maximum hold mode, until there is no significant increase in any of the maximum hold values. No significant increase would be less that 3 dB.

The data is then to be analyzed to determine the maximum of the peak power values and the lowest frequency where the peak value is -20 dB relative to the maximum peak value. The highest frequency associated with the upper

2. If the UUT has more than one mode of operation, a complete set of all measurements are required for each mode. If the normal operation of any frequency hopping mode involves a gating function, this should be active as appropriate.

-10 dB amplitude point will also be determined from this data.

To be deemed compliant (for the above peak power measurements), the recorded maximum hold values are to be converted to EIRP and no EIRP value is to exceed -24 dBm in the 3 MHz resolution bandwidth. The frequency where the maximum peak power value occurred must be greater than 24.075 GHz. In addition, the frequency of the -20 dB point on the lower frequency end of the UUT spectrum must be greater than or equal to 22 GHz and the -10 dB point at the upper frequency end of the UUT spectrum must be less than or equal to 29 GHz.

Peak power measurements of the UUT are also required with the frequency hopping function off. The UUT is to be operated at the frequency at which the maximum peak power value was measured with the frequency hopping on.

For these measurements, the spectrum analyzer is set to the peak detector mode with maximum hold, a resolution bandwidth of 1 MHz and a video bandwidth of at least 3 MHz. The UUT spectrum is to be scanned over the expected frequency range that spans the spectrum between, at least, the 20 dB down emission levels. The UUT spectrum is to be scanned at a rate that provides 1 millisecond for each 1 MHz frequency bin. The UUT spectrum is to be scanned until there is no significant increase in the measured maximum hold values. For the UUT to be in compliance the bandwidth of this non-hopping signal must be at least 10 MHz at the -10 dB points.

Measurement of Average Power Levels

These measurements are to be carried out using the first test setup. The UUT antenna is to be pointed directly at the measurement antenna with the polarizations matched. With the UUT operating in the frequency hopping mode and with the gating active (if appropriate) and the spectrum analyzer set to the RMS detector with resolution bandwidths of 1 kHz and 1 MHz and video bandwidth of at least 3 MHz, the average EIRP emission levels are to be measured across the 22 to 29 GHz frequency range. The average emissions are to be measured over a 1 millisecond time interval for each 1 MHz interval. This average EIRP measurement is to be repeated, with the analyzer in the maximum hold mode, until there is no significant increase in any of the maximum hold values. No significant increase would be less that 3 dB. The maximum emission level for each 1 MHz interval is to be recorded. The spectrum analyzer sweep time, sweep width, and number of frequency bins (number of points on the display) need to be properly coordinated to yield the required data. For example, if there are 1000 frequency bins, set the measurement span to 1 GHz and set the sweep time to 1 second. This will result in a 1 millisecond per bin integration time and a 1 MHz frequency interval per bin. The maximum power values resulting from multiple sweeps is to be determined for each frequency bin as the frequency hopping period[3] may last longer than the 1 millisecond integration time. The measurement bandwidth for the UUT may have to be segmented to obtain the full data set. For the above example, only 1 GHz is covered for the set of selected parameters. To be deemed

3. The frequency hopping period is the time it takes to revisit the same frequency in the hop set.

compliant, the maximum measured power levels must all be converted to EIRP values and no resulting EIRP value is to exceed -41.3 dBm/MHz. In the 22.01-23.12 GHz, and 23.6-24 GHz bands, the EIRP values cannot exceed -61.3 dBm/MHz.

Measurement of Out-Of-Band Average Power Levels

These measurements are to be performed using the first test setup. Again the UUT antenna is to be aligned with the measurement antenna. With the UUT operating in the frequency hopping mode with the gating active as appropriate and the spectrum analyzer set to the RMS detector with a resolution bandwidth of 1 MHz and a video bandwidth of at least 3 MHz, average EIRP emission levels are to be determined based on the measured power levels.

For these measurements, the spectrum analyzer should be operated in the zero span mode and in the maximum hold mode. The power is to be averaged over a 1 millisecond interval and repeated until the amplitude stabilizes. These measurements are to be performed with the UUT turned on and then turned off. The measurements are to be performed at 1 GHz intervals from the low end of the test setup applicable frequency range to the frequency of the lower -10 dB bandwidth point. The applicable frequency range of the measurement setup is defined in the section on calibration and environmental signal monitoring. The average power is to also be measured with the UUT on and then turned off at the -20 dB lower frequency point. The -20 dB lower frequency was determined earlier. The average power is to be measured from the highest -10 dB bandwidth point to the highest applicable frequency in 1 GHz steps. The power is to be averaged over a 1 millisecond interval and repeated until the amplitude stabilizes. These measurements are to be performed with the UUT turned on and then turned off.

For certification, the measured average power levels are to be converted to EIRP values and the maximum allowable EIRP levels (within the applicable frequency range of the measurement setup) are not to exceed -61.3 dBm/MHz below 22 GHz and not to exceed -51.3 dBm/MHz from 29 to 31 GHz and not to exceed -61.3 dBm/MHz above 31 GHz.

Measurement of Average Power in the 1164-1700 MHz Frequency Range

These measurements are to be carried out using the second test setup. The UUT antenna is to be pointed directly at the measurement antenna. The UUT is to be operated in the frequency hopping mode and with the gating active if appropriate. The spectrum analyzer is to be operated in the zero span mode using the RMS detector function with a resolution bandwidth of 1 MHz and a video bandwidth of at least 3 MHz and in the maximum hold mode. At each fixed frequency, the power is to be averaged over a 1 millisecond interval and repeated until the amplitude stabilizes. These measurements are to be performed with the UUT turned on and then with the UUT turned off.

Average power measurements are to be made at the following frequencies: 1171.5 MHz, 1176.5 MHz, 1181.5 MHz, 1227.6 MHz, 1575.4 MHz, and 1610 MHz using both the 1 kHz and 1 MHz resolution bandwidths. Measurements are then to be made in 100 MHz steps to the

highest frequency of the test setup applicable frequency range using only the 1 MHz resolution bandwidth.

For certification, the EIRP values determined from the measured power levels at each frequency with the UUT turned on cannot exceed the levels specified in 47 C.F.R. Sections 15.515 (d) and (e).

CALIBRATION AND ENVIRONMENTAL SIGNAL MONITORING

The gain/loss values for the various elements of the 22 to 29 GHz and the 1 to 3 GHz measurement setups must be determined over the applicable frequency. These elements include:

- The propagation path between the UUT and the measurement antenna;
- The measurement antennas;
- All components from the output of the measurement antenna to the input of the spectrum analyzer.

These gain/loss values are to be used to convert the power levels measured by the spectrum analyzer to the EIRP of the UUT. As part of this test setup evaluation, the UUT should be turned on to evaluate if the low noise preamplifier or spectrum analyzer is being saturated. If saturation occurs, attenuation can be properly employed to eliminate the problem. This attenuation, if any must be included in the gain/loss determination.

The applicable frequency range, for each measurement setup will be determined from the operating frequency range of the measurement antenna and the low-noise preamplifier in combination. For example, if the antenna is rated from 18 to 28 GHz and the low-noise preamplifier from 20 to 30 GHz, the applicable frequency range of the measurement setup is 20 to 28 GHz. The applicable frequency range is used to establish the frequency range over which measurements are to be conducted.

If the measurements are not performed in an anechoic chamber, the signal environment must be monitored to determine if there are any extraneous signals. In cases where such signals are present, in the frequency ranges of concern, steps should be taken to turn off the signals or to shield them from the test setup. If the presence of such signals is significant the test site should not be used. If the presence of such signals is relatively minimal the data for those effected frequencies should be ignored.

ENCLOSURE C

GUIDANCE FOR COMPLIANCE MEASUREMENTS OF GATED ULTRAWIDEBAND SIGNALS

INTRODUCTION

The purpose of this document is to provide guidance on performing the compliance measurements for gated ultrawideband (UWB) signals.

GATED SYSTEM PARAMETERS REQUIRED FOR DEVICE CERTIFICATION

The emission characteristics of a gated UWB signal are defined by its system parameters. The applicant requesting device certification should be required to provide the following information: signal modulation characteristics, gating pattern (including gating on and gating off times), antenna polarization, and center frequency of the UWB signal. This information will define a specific mode of operation for the unit under test (UUT). If there are multiple operating modes the system parameters for each mode are to be provided by the applicant and each of the multiple modes is to be tested for certification.

OVERVIEW OF CERTIFICATION MEASUREMENT PROCEDURES

The general measurement setup used in the certification measurements is shown in Figure 1.

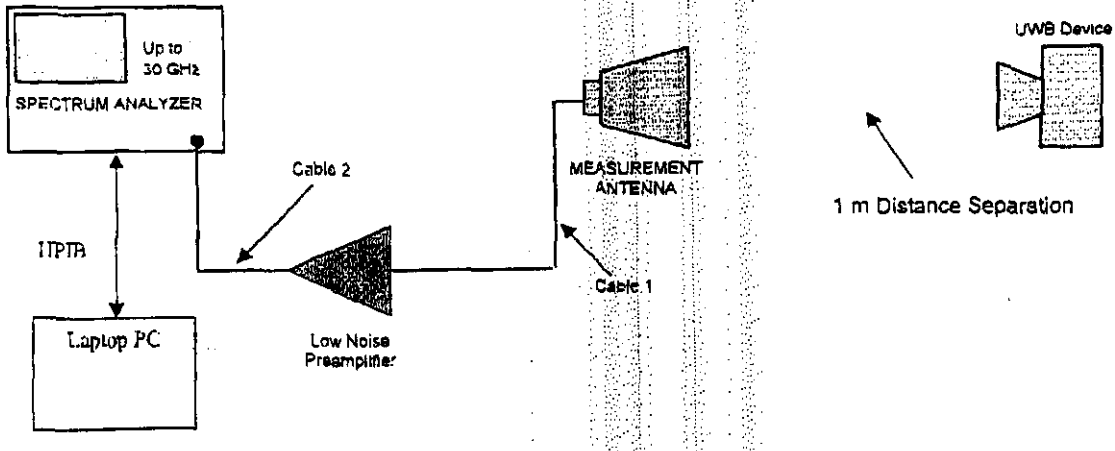

Figure 1. General Test Setup

The certification measurements could require multiple test setups, depending on the UWB transmitter category (e.g., imaging, ground penetrating radar, surveillance system) and the characteristics of the specific test equipment. All test setups will use the equipment shown in

Figure 1, the only difference will be the applicable frequency range of the preamplifier and the measurement antenna.

The test setup will normally use a 1 meter separation distance with no surface that could provide significant reflections in the vicinity of the test setup. The UUT including the transmit antenna is to be located at a height of approximately 1 to 2 meters. The required commercially available measurement equipment includes:

- A spectrum analyzer with peak and RMS detectors, maximum hold[1] capability, and a minimum upper frequency capability of 30 GHz;
- An appropriate measurement antenna(s) with a gain on the order of 10 to 15 dBi at the center frequency of the UUT emission. This antenna is to be oriented in the test setup such that the polarization is aligned with the polarization of the antenna used by the UUT. The measurement is to be at the same height as the UUT antenna.;
- A low noise preamplifier with a gain of at least NF + L + 5 dB, where NF is the noise figure of the spectrum analyzer, and L is the loss of the cable connecting the low noise preamplifier to the spectrum analyzer. The values of NF and L may be determined from specifications or measurements. The low noise preamplifier should have a noise figure of less than 2 dB;
- Low loss cable to connect measurement antenna to low noise preamplifier input with a cable loss on the order of 0.2 dB;
- Suitable cable(s) are required to connect the low noise preamplifier output to the spectrum analyzer. This connection might require a variable attenuator to avoid saturation;
- A personal computer connected to the spectrum analyzer is recommended to control the analyzer and to store the measured data.

Measurement of Peak Power Levels

The UUT antenna is to be pointed directly at the measurement antenna with the polarization of the UUT and the measurement antenna matched. With the UUT operating with the gating active[2] the spectrum analyzer is to be set to the peak detector mode (with maximum hold) with a resolution bandwidth of 3 MHz and video bandwidth of at least 3 MHz. The peak power levels of the UUT should be measured across the expected range of the -20 dB bandwidth

1. The maximum hold capability retains the maximum value for each point on the spectrum analyzer display over the selected number of display scans.

2. If the UUT has more than one mode of operation, a complete set of all measurements are required for each mode.

of the UUT emission over a 1 millisecond dwell time for each segment of the sweep. This peak power measurement is to be repeated, with the analyzer in the maximum hold mode, until there is no significant increase in any of the maximum hold values. No significant increase would be less that 3 dB.

The data is then to be analyzed to determine the maximum of the peak power values and the lowest frequency where the peak value is -20 dB and -10 dB relative to the maximum peak value. The highest frequency associated with the upper -10 dB and -20 dB amplitude points will also be determined from this data. If either -20 dB point is not contained within this initial measurement span, then it will be necessary to expand the frequency range of the measurement of the UUT peak radiated emissions.

The recorded maximum hold values are to be converted to EIRP and these values compared to the appropriate rules for compliance.

Measurement of Average Power Levels

The UUT antenna is to be pointed directly at the measurement antenna with the polarizations matched. With the UUT operating with the gating active (if appropriate) and the spectrum analyzer set to the RMS detector (with maximum hold) with a resolution bandwidth of 1 MHz and video bandwidth of at least 3 MHz, the average EIRP emission levels are to be measured across the range of the UUT -10 dB bandwidth. The average emissions are to be measured over a 1 millisecond time interval for each 1 MHz interval. This average EIRP measurement is to be repeated, with the analyzer in the maximum hold mode, until there is no significant increase in any of the maximum hold values. No significant increase would be less than 3 dB. The maximum emission level for each 1 MHz interval is to be recorded. The spectrum analyzer sweep time, sweep width, and number of frequency bins (number of points on the display) need to be properly coordinated to yield the required data. For example, if there are 1000 frequency bins, set the measurement span to 1 GHz and set the sweep time to 1 second. This will result in a 1 millisecond per bin integration time and a 1 MHz frequency interval per bin. The maximum power values resulting from multiple sweeps is to be determined for each frequency bin as the gating period may last longer than the 1 millisecond integration time. The measurement bandwidth for the UUT may have to be segmented to obtain the full data set. For the above example, only 1 GHz is covered for the set of selected parameters. The maximum measured power levels must all be converted to EIRP values and compared to the appropriate rules for compliance.

Measurement of Out-Of-Band Average Power Levels

Again the UUT antenna is to be aligned with the measurement antenna. With the UUT operating with the gating active as appropriate and the spectrum analyzer set to the RMS detector with a resolution bandwidths of 1 kHz and 1 MHz and a video bandwidth of at least 3 MHz, average EIRP emission levels are to be determined based on the measured power levels. In the frequency bands 1164-1240 MHz and 1559-1610 MHz, measurements using both resolution bandwidths are required. For all other out-of-band frequencies, only measurements using a 1

MHz resolution bandwidth are required.

For these measurements, the spectrum analyzer should be operated in the zero span mode and in the maximum hold mode. The frequency settings for the spectrum analyzer are to be selected judiciously to examine conformance with the applicable emission limits for the different categories of UWB devices (e.g., imaging, hand-held). The measured power is to be averaged over a 1 millisecond interval and repeated until the amplitude stabilizes. These measurements are to be performed with the UUT turned on and then turned off.

The measured average power levels are to be converted to EIRP values and compared to the appropriate rules for compliance.

CALIBRATION AND ENVIRONMENTAL SIGNAL MONITORING

The gain/loss values for the various elements of the measurement setups must be determined over the applicable frequency. These elements include:

- The propagation path between the UUT and he measurement antenna;
- The measurement antennas;
- All components from the output of the measurement antenna to the input of the spectrum analyzer.

These gain/loss values are to be used to convert the power levels measured by the spectrum analyzer to the EIRP of the UUT. As part of this test setup evaluation, the UUT should be turned on to evaluate if the low noise preamplifier or spectrum analyzer is being saturated. If saturation occurs, attenuation can be properly employed to eliminate the problem. This attenuation, if any must be included in the gain/loss determination.

If the measurements are not performed in an anechoic chamber, the signal environment must be monitored to determine if there are any extraneous signals. In cases where such signals are present, in the frequency ranges of concern, steps should be taken to turn off the signals or to shield them from the test setup. If the presence of such signals is significant the test site should not be used. If the presence of such signals is relatively minimal the data for those effected frequencies should be ignored.